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AUBURN GS
RETAINING WALL AND TRAINING WALL
CONCRETE CONDITION SURVEY

Report No. 91-37-K

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ABSTRACT

An investigation was undertaken to evaluate the condition of the concrete in the retaining wall east of the main dam and the training wall east of the intake channel. The investigation consisted of visual observation, concrete coring and laboratory testing. In the retaining wall, deteriorated concrete was observed near the main dam and sections of poor quality concrete were encountered in the cores. Undercutting of the wall, due to flowing water, may also be occurring. The east face of the training wall was extensively deteriorated, and in the west face, open construction joints were present. The concrete cores drilled from the wall contained sections of poor quality concrete. Remedial action is required to restore both structures to their original condition and to arrest the deterioration of the concrete.

job	file	date	report no.
42-179-481	842.5 AUB	April 9, 1991	91-37-K

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To Mr. O. Bernaus
Manager
Civil Maintenance Department
Hydraulic Generation Group

Attn: Mr. L.W. Coley/Ms. H.S. Zdzienicki

AUBURN GS
RETAINING WALL AND TRAINING WALL
CONCRETE CONDITION SURVEY

1.0 INTRODUCTION

At the request of Ms. H.S. Zdzienicki of the Civil Maintenance Department, an investigation was undertaken by the Civil Research Department to evaluate the condition of the concrete in the Auburn GS retaining wall east of the main dam and the training wall east of the intake channel. The evaluation consisted of visual observation, concrete coring and laboratory testing of specimens prepared from the concrete cores. The results of the investigation are summarized in this report.

In addition, an attempt was made to obtain ultrasonic pulse velocity readings through the concrete using the drill holes in the training wall. Readings could not be obtained probably due to the presence of sections of poor quality concrete and open construction joints. Therefore, no ultrasonic pulse velocity readings have been reported.

The field portion of this investigation was carried out from November 5 to 9 and on December 5, 1990. The concrete coring was conducted by the Rock Sciences Section and the remainder of the investigation by the Concrete Technology Section.

2.0 VISUAL OBSERVATIONS AND CONCRETE CORING

The retaining wall east of the Auburn GS main dam is shown in Figures 1 to 3. The concrete has deteriorated near the main dam and at several locations along the top of the wall.

Three cores (Cores 1, 2 and 6) were drilled from the wall to assess quality of the concrete and to supply specimens for laboratory testing. The location of the core holes is shown in Figure 1, and the concrete core log is given in Appendix A.

Core 1 was drilled vertically into the bedrock from a section of the wall exhibiting surface deterioration. The portion of the core drilled into the bedrock was retrieved as rubble. The drill water was lost near the bottom of the hole in the bedrock, indicating that an open crack may be present or undercutting of the wall may have occurred. This could not be confirmed by visual observation because of access restrictions during the field work.

Core 2 was drilled vertically from a section of the retaining wall that did not exhibit surface deterioration. Near the lower portion of the hole, a section of poor quality concrete exhibiting extensive cracking was retrieved.

Core 6 was drilled horizontally from the retaining wall at the east end of the dam. The concrete was found to be cracked to a depth of 120 mm from the west face of the wall. Beyond this depth, the concrete was generally sound. The wall below the core location exhibited more extensive deterioration (Figure 3).

The concrete in the training wall east of the intake channel, as shown in Figures 4 to 6, appeared to range from good to poor condition. Several locations on the east face of the wall exhibited extensive surface deterioration. Other sections of the wall had been repaired, including horizontal joints in the west face of the wall.

Three cores (Cores 3, 4 and 5) were drilled vertically from the training wall. The location of the drill holes is shown in Figure 4, and a description of the cores is given in Appendix A. Cores 3 and 4 were from areas in the wall exhibiting deterioration and Core 5 was from a section of the wall in fair condition. At all locations, the drill water was lost at a horizontal joint that appeared to have been repaired. Sections of the cores were recovered as rubble or voids were present, indicating the existence of poor quality concrete.

A petrographic examination of selected cores, reported in Appendix B, identified the aggregates as being primarily limestone, with Core 6 containing some granite gneiss. Core 1 contained large "plums", up to 125 mm in size, around which the core breaks occurred. In the remaining cores, the maximum nominal size of the coarse aggregate ranged from 40 to 100 mm. The core breaks in these cores also occurred around the coarse aggregate. The distribution of the aggregates was classified as fair, primarily because of the presence of a high proportion of large size coarse aggregate.

3.0 LABORATORY TESTING

Specimens were prepared from the concrete cores and tested for compressive strength (CAN/CSA - A23.2 - 14C), density, and absorption (ASTM C 642). The results of the tests are given in Table 1.

The specimens tested for compressive strength were in a saturated surface dry condition (SSD). Sections of the cores were selected so that the maximum size of the aggregate in the core would not exceed 30 mm. Specimens prepared from the cores drilled vertically from the retaining wall (Cores 1 and 2) had compressive strengths that ranged from 12.6 to 22.5 MPa, with an average value of 18.9 MPa. The specimens prepared from the cores drilled from the training wall (Cores 3, 4 and 5) had compressive strengths that ranged from 17.0 to 32.5 MPa and averaged 23.3 MPa.

The density and absorption of the specimens prepared from the concrete cores drilled from the retaining wall averaged 2401 kg/m^3 and 5.7%, respectively, and for the training wall these properties averaged 2395 kg/m^3 and 5.2%. These results are in the range generally associated with a good quality concrete.

4.0 CONCLUSIONS

Deterioration of the concrete was observed in the retaining wall, particularly at the waterline. The concrete coring determined that sections of poor quality concrete also existed in the wall at other locations. Remedial action is required to rehabilitate the retaining wall, particularly in the areas exhibiting deterioration. Undercutting of the wall due to the action of the water may also be a problem that could require remedial action.

The concrete in the east face of the training wall was extensively deteriorated. In the interior of the wall, sections of poor quality concrete and voids were encountered. During repairs, it is anticipated that sections of poor quality concrete will be encountered within the wall. On the west face of the wall, open horizontal construction joints were identified. Remedial action is required to rehabilitate this wall and arrest the deterioration of the concrete.

Approved by:

for J.B. Brown
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Concrete Technology Section

EJM:td

TABLE 1

AUBURN GS
LABORATORY TESTING OF CONCRETE CORES

Specimen Identification		Diameter of Core (mm)	Compressive Strength (MPa)	Density - SSD (kg/m^3)	Absorption (%) 48-Hour Immersion
Core 1	1-1	99	15.2	2461	-
	1-2	99	21.4	2369	-
	1-3	-	-	2364	6.1
	1-4	-	-	2400	5.7
Core 2	2-1	-	-	2361	5.8
	2-2	99	22.0	2403	-
	2-3	99	12.6*	2403	-
	2-4	99	22.5	2391	-
	2-5	-	-	2427	5.2
	2-6	99	19.5	2428	-
Average of Cores 1 & 2			18.9	2401	5.7
Core 3	3-1	-	-	2421	4.7
	3-2	86	17.0*	2424	-
	3-3	86	22.0*	2448	-
	3-4	-	-	2428	4.8
	3-5	86	32.1	2385	-
Core 4	4-1	86	23.2*	2397	-
	4-2	-	-	2453	4.5
Core 5	5-1	86	32.5	2315	-
	5-2	-	-	2319	5.6
	5-3	-	-	2370	6.3
	5-4	86	18.1	2392	-
	5-5	86	21.9	2354	-
	5-6	86	19.5	2420	-
	5-7	-	-	2402	5.5
Average of Cores 3,4 & 5			23.3	2395	5.2
Core 6	6-1	-	-	2451	4.3
	6-2	-	-	2528	3.3
	6-3	99	20.4*	2439	-

* The length to diameter ratio of the specimen was less than 2.0; therefore, a correction factor was applied to the compressive strength test result as per the test procedure.

NOTES:

(1) Compressive Strength: Specimen tested as per CAN/CSA-A23.2-14C. Specimen tested in a saturated surface dry condition (SSD).

(2) Absorption 48-Hour Immersion: Specimen tested for absorption after immersion in accordance with ASTM C 642.

Figure 1 The locations of Cores 1, 2 and 6 in the retaining wall east of the Auburn GS main dam are indicated.

Figure 2 The location of Core 1 drilled from a deteriorated area of the retaining wall is indicated.

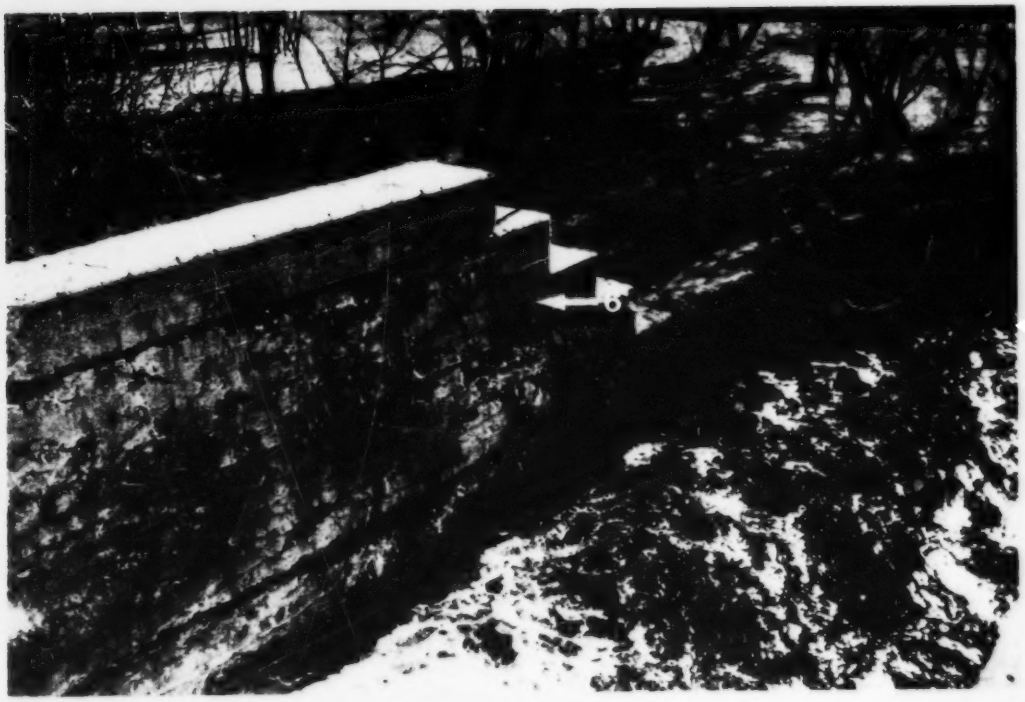

Figure 3 Deterioration of the concrete in the retaining wall near the main dam is shown. Note that the deterioration is most severe at the waterline. The approximate location of Core 6 is indicated.

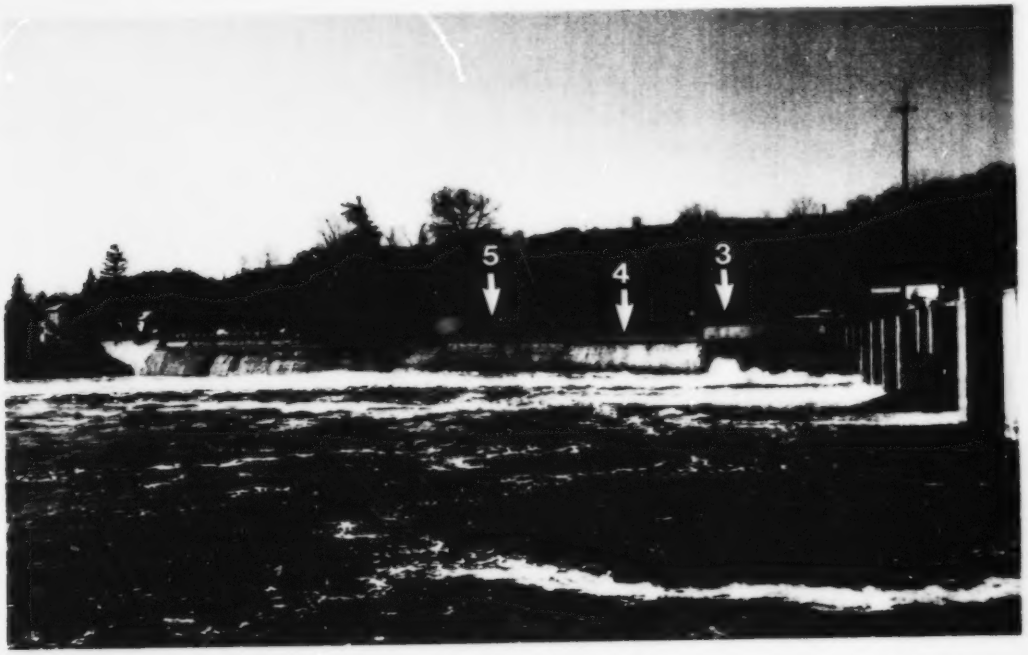

Figure 4 The location of Cores 3 to 5 in the training wall east of the intake channel are shown. Note the deteriorated concrete along the east face of the wall.

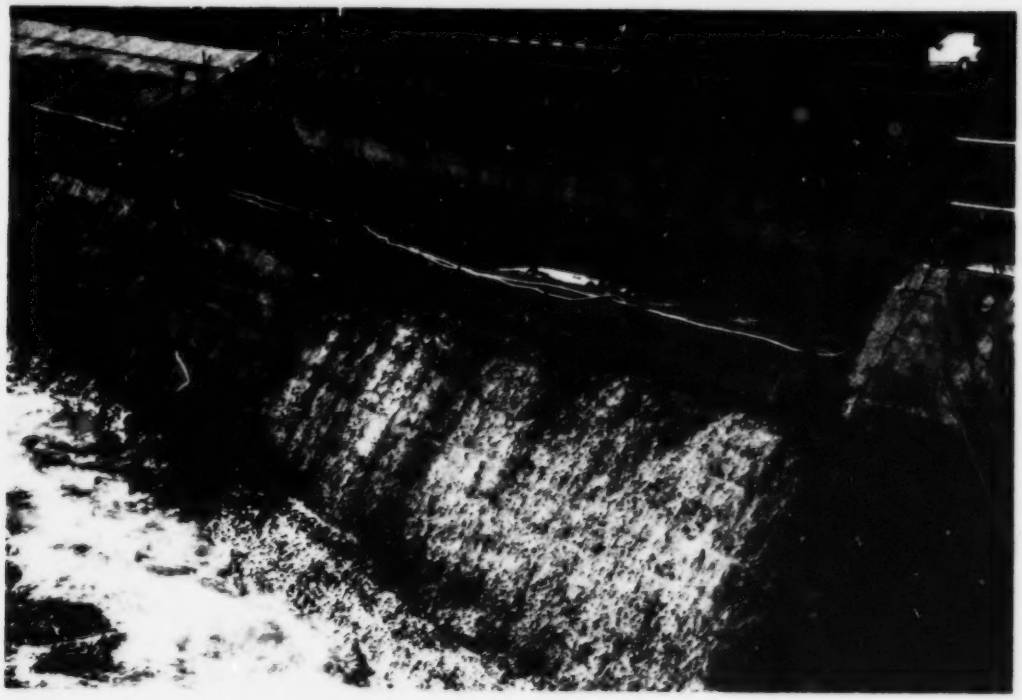

Figure 5 Deteriorated concrete along the east face of the training wall. The drilling of Core 5 is shown.

Figure 6 Drilling of Core 5 in the training wall. Note the repairs made to horizontal joints in the west face of the wall. During drilling, drill water was lost at the upper joint.

APPENDIX A

AUBURN GS
CONCRETE CORE LOG

AUBURN GS
CONCRETE CORE LOG

Core Number	Depth in Core Hole (mm)	Remarks
Core 1 •Retaining wall	0 - 2030 1680 1830 - 2030 1980	- core drilled into bedrock (Figure A1) - contact between concrete and bedrock - contact retrieved partially intact - core consisted of bedrock and was recovered as rubble. - drill water lost
- The core was drilled vertically from a section of the retaining wall which exhibited surface deterioration of the concrete. - The contact between the bedrock and concrete was retrieved partially intact; however, staining of the concrete, possibly caused by an open joint, was observed. - The aggregate was predominately rounded with some aggregate up to 125 mm in size. - The distribution was classified as good and the grading as poor. - The core breaks occurred around the large aggregate.		
Core 2 •Retaining wall	0 - 2210 810 - 910 1700 - 2210	- depth of core drilled (Figure A1) - concrete contained poor quality mortar and core was recovered as rubble - core extensively cracked
- The core was drilled vertically from a section of the retaining wall in which no surface deterioration was observed. - The aggregate was predominately rounded with a nominal maximum size of 50 mm. The concrete did not contain large stones as did Core 1. - The distribution and grading of the aggregates were classified as good. - The core breaks occurred around the aggregate.		
Core 3 •Training wall	0 - 2950 1550 2340	- depth of core drilled (Figure A2) - evidence of an open joint or crack - lost water during drilling - portion of core recovered as rubble
- The core was drilled vertically from the training wall in an area in which the concrete had deterioration along the face of the wall. - The drill water was lost from a horizontal construction joint or crack. - The aggregate was predominately rounded and up to 75 mm in size. - The distribution was classified as good and the grading as fair, primarily because of the high proportion of large size aggregate. - The core breaks occurred around the aggregate.		
Core 4 •Training wall	0 - 1680 0 - 940 180 - 330 480 - 580	- depth of core drilled (Figure A2) - depth of core retrieved; remainder of core could not be retrieved - core retrieved as rubble - void encountered
- The core was drilled vertically from the training wall in an area in which the concrete had deteriorated. - The aggregate was predominately rounded and up to 90 mm in size. - The distribution was classified as good and the grading as fair, primarily because of the high proportion of large size aggregate. - The core breaks occurred around the aggregate.		

AUBURN GS
CONCRETE CORE LOG CONT'D

Core Number	Depth in Core Hole (mm)	Remarks
Core 5 •Training wall	0 - 2900 250 1370 - 1450 1800 2110 - 2260	- depth of core drilled (Figure A2) - location of possible joint - intersected piece of wood - joint intersected (joint intact in core) - core recovered as rubble
- The core was drilled vertically from the training wall in an area in which the concrete appeared to be in fair condition. - The aggregate was predominately rounded and up to 100 mm in size. - The distribution was classified as good and the grading as fair, primarily because of the large proportion of large size aggregates. - The core breaks occurred around the aggregate.		
Core 6 •Retaining wall	0 - 910 250 - 300 790 - 910	- core drilled horizontally from east to west (Figure A1) - intersected piece of wood - core cracked showing evidence of deterioration
- The core was drilled horizontally from east to west through a large block at the east end of the dam above the retaining wall. - The aggregate was predominately rounded with a maximum size of 75 mm. - The distribution was classified as good and the grading as fair, primarily because the concrete contained numerous large aggregate. - The core breaks occurred around the aggregate.		

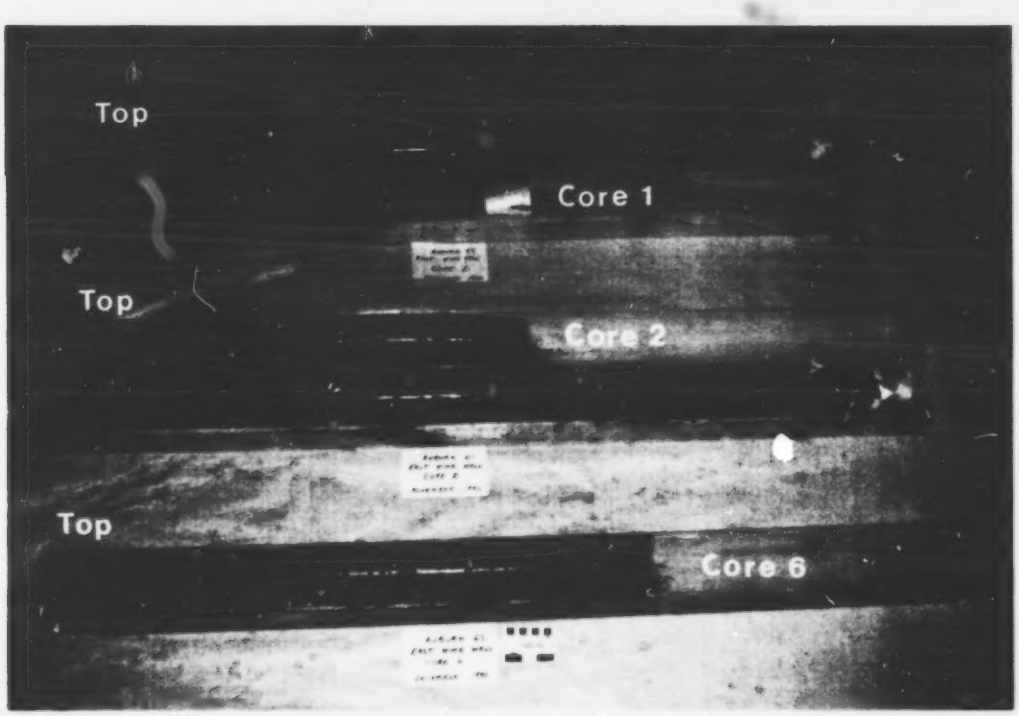

Figure A1 Shown above are Cores 1 and 2 drilled vertically and Core 6 drilled horizontally from the retaining wall.

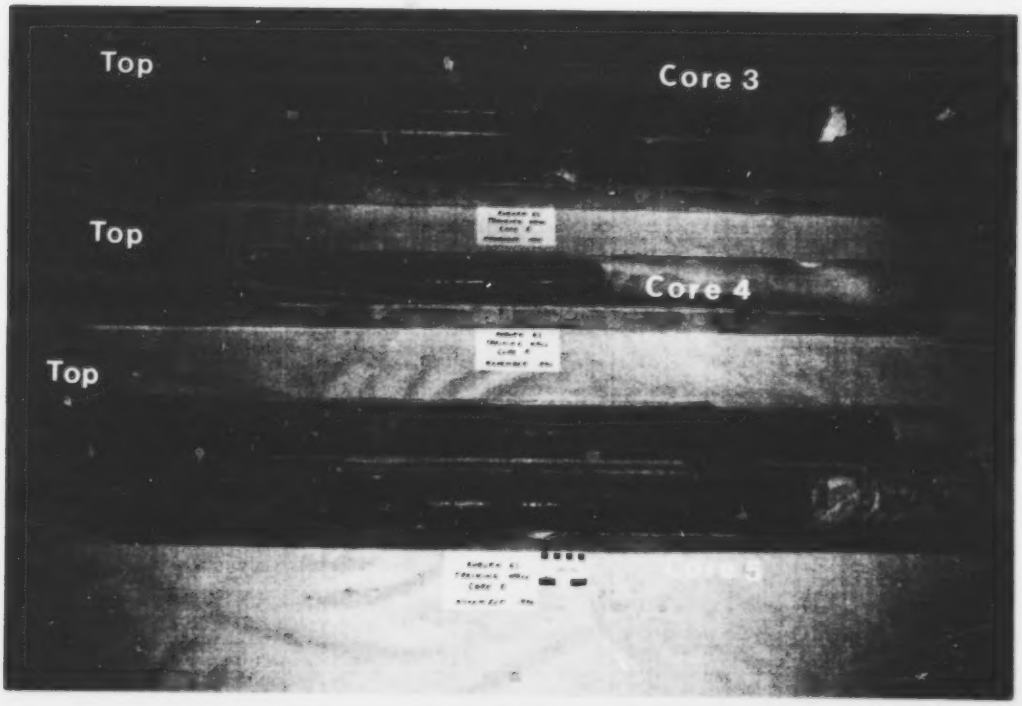

Figure A2 Shown above are Cores 3, 4 and 5 drilled vertically from the training wall.

APPENDIX B

AUBURN GS
PETROGRAPHIC EXAMINATION OF CONCRETE CORES

ONTARIO HYDRO RESEARCH DIVISION
PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE
ADAPTED FROM: ASTM C 856

Project: AUBURN GS
Region : CENTRAL Area: PETERBOROUGH Job No.: 42-179-481
Structure: EAST RETAINING WALL Report No.: SN91-1-K File No.: 842.5 AUB
Date Issued: 91.02.13

Sample Type : Core[X] Cylinder[ ] Chunk[ ] Other[ ]

Sample Description: Section (interval 1700 to 1950 mm, nominal 99 mm diameter) of Core 2 drilled vertically from the east retaining wall. The concrete has undergone approx. 80 years of exposure in an environment of high rel. humidity.

*Sample Preparation: Freshly broken/saw cut/drilled surface[X] Polished face[ ]
Weathered surface[ ] Thin Section[ ]/No.

CONCRETE

Hit with hammer	: Ring[X]	Dull[ ]		
Break with fingers	: Particles not dislodged[X]	Powdery[ ]	Friable[ ]	
During sawing	: Clean cut[X]	Breaks easily[ ]		
Cement/coarse aggregate bond	: Good[ ]	Partial[X]	Poor[ ]	
Cement/fine aggregate bond	: Good[X]	Partial[ ]	Poor[ ]	
Presence of honeycombing	: Not observed[X]	Minor[ ]	Extensive[ ]	

COARSE AGGREGATE

Source	: Unknown - construction records unavailable.				
% of total volume	: 30-35 %	Visual estimate[X]		Point count[ ]	
Material type	: Gravel[X]	Quarried[ ]	Mixture[ ]	Other[ ]	
Shape	: Rounded[X]	Partly crushed[ ]		100% Crushed[ ]	
Distribution	: Even[ ]	Uneven[X]		Chaotic[ ]	
Nominal size	: 50 (mm)				
Maximum size	: 50 (mm)				
Preferred orientation	: Present[ ]	Not observed[X]			

LITHOLOGICAL TYPE	% OF COARSE AGGREGATE	REACTION RIMS/GEL/ FRACTURES	REMARKS
Limestone	100	A few tightly fractured particles. Fractures do not appear to extend into the cement paste.	Most of the fractures appear to have originated before the aggregate was placed in the concrete.

FINE AGGREGATE

Source	: Unknown - construction records unavailable.				
% of total volume	: 45-50 %	Visual estimate[X]		Point count[ ]	
Material type	: Natural[X]	Manufactured [ ]	Mixture[ ]	Other[ ]	
Shape	: Rounded[X]	Subrounded[X]	Subangular[ ]	Angular[ ]	
Distribution	: Even[ ]	Uneven[X]		Chaotic[ ]	
Perferred orientation	: Present[ ]	Not observed[X]			

CEMENT MATRIX

% of total volume : 10-15 % Visual estimate[X] Point count[ ]
Appearance of broken surface: Subtransluescent[ ] Dull[X] Chalky[ ]
Colour : Grey[ ] Light grey[X] White[X] Brown[ ] Other:
Colour distribution: Even[ ] Mottled[X] Gradational[ ]
Bleeding :-Extensive[ ] Minor[ ] Not observed[X]
Carbonation : Surficial only[ ] Along fractures[ ] Partial[ ] Total[ ]
Slag cement : Observed[ ] Not observed[X]
Fly ash : Observed[ ] Not observed[X]

VOIDS

% of total volume : 3-5 % Visual estimate[X] Point count[ ]
Distribution : Even[X] Uneven[ ] Clustered[ ]
Shape : Spherical[ ] Nonspherical[ ] Ellipsoidal[ ] Irregular[X]
Entrained air : Air-entrained[ ] Non-air-entrained[X]
Interior lustre : Dull[X] Shining[ ]
Interior condition: Empty[X] Lined[ ] Partly filled[ ] Totally filled[ ]
% Voids with mineralization: Most[ ] About half[ ] Few[ ] None[X]
Mineralization : Alkali-silica gel[ ] Ettringite[ ] Portlandite[ ]
Calcium carbonate[ ]

CRACKS

Amount : Extensive[ ] Occasional[ ] None[X]
Continuity and Distribution:

Orientation : Vertical[ ] Horizontal[ ] Random[ ]
Location : Through aggregate particles[ ] Around aggregate particles[ ]
Width (mm) : Range to Average
% filled : %
Filling material: Alkali-silica gel[ ] Ettringite[ ] Portlandite[ ]
Calcium carbonate[ ] Other:
Associated with embedded items: Yes[ ] No[ ]

EMBEDDED ITEMS Yes[X] No[ ]

Description: 2 tie wires in core section.
Condition : Clean[X] Corroded[ ] Decayed[ ]
Size (mm) : 5 mm diameter.
Location/Orientation: Located halfway down the length of the core orientated
Other : perpendicular to the core axis.

GENERAL COMMENTS:
* Results are based on a visual examination of a core section only, and not all items listed above could be evaluated.

Distribution: MR. E.J. MCCOLM CIVIL RESEARCH
MR. J. VITANYI/MR. M. F. EVERITT CIVIL RESEARCH
842.5 AUB KR163
842.5 (P) OFFICIAL RECORD

Approved by: _____ Submitted by: _____
Report No.: SN91-1-K

ONTARIO HYDRO RESEARCH DIVISION
PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE
ADAPTED FROM: ASTM C 856

Project: AUBURN GS
Region : CENTRAL
Structure: TRAINING WALL
Area: PETERBOROUGH
Report No.: SN91-2-K
Job No.: 42-179-481
File No.: 842.5 AUB
Date Issued: 91.02.13

Sample Type : Core[X] Cylinder[ ] Chunk[ ] Other[ ]

Sample Description: Section (interval 170-340 mm, nominal 86 mm diameter) of Core 3, drilled vertically from the training wall. The concrete has undergone approx. 80 years of exposure in an environment of high relative humidity.

* Sample Preparation: Freshly broken/saw cut/drilled surface[X] Polished face[ ]
Weathered surface[ ] Thin Section[ ]/No.

CONCRETE

Hit with hammer	: Ring[X]	Dull[ ]		
Break with fingers	: Particles not dislodged[X]	Powdery[ ]	Friable[ ]	
During sawing	: Clean cut[X]	Breaks easily[ ]		
Cement/coarse aggregate bond	: Good[X]	Partial[ ]		Poor[ ]
Cement/fine aggregate bond	: Good[X]	Partial[ ]		Poor[ ]
Presence of honeycombing	: Not observed[X]	Minor[ ]		Extensive[ ]

COARSE AGGREGATE

Source	: Unknown - construction records unavailable.			
% of total volume	: 35-40 %	Visual estimate[X]		Point count[ ]
Material type	: Gravel[X]	Quarried[ ]	Mixture[ ]	Other[ ]
Shape	: Rounded[X]	Partly crushed[ ]		100% Crushed[ ]
Distribution	: Even[ ]	Uneven[X]		Chaotic[ ]
Nominal size	: 40 (mm)			
Maximum size	: 40 (mm)			
Preferred orientation	: Present[X]	Not observed[ ]		

LITHOLOGICAL TYPE	% OF COARSE AGGREGATE	REACTION RIMS/GEL/ FRACTURES	REMARKS
Limestone	100	A few tightly fractured particles. Fractures do not appear to extend into the cement paste.	Most fractures appear to have originated before the aggregate was placed in the concrete.

FINE AGGREGATE

Source	: Unknown - construction records unavailable.				
% of total volume	: 30-35 %	Visual estimate[X]			Point count[ ]
Material type	: Natural[X]	Manufactured [ ]	Mixture[ ]		Other[ ]
Shape	: Rounded[X]	Subrounded[X]	Subangular[ ]		Angular[ ]
Distribution	: Even[X]	Uneven[ ]			Chaotic[ ]
Perferred orientation	: Present[ ]	Not observed[X]			

CEMENT MATRIX

% of total volume : 15-20 % Visual estimate[X] Point count[ ]
Appearance of broken surface: Subtransluescent[ ] Dull[X] Chalky[ ]
Colour : Grey[ ] Light grey[X] White[ ] Brown[ ] Other:
Colour distribution: Even[X] Mottled[ ] Gradational[ ]
Bleeding :-Extensive[ ] Minor[X] Not observed[ ]
Carbonation : Surficial only[ ] Along fractures[ ] Partial[ ] Total[ ]
Slag cement : Observed[ ] Not observed[X]
Fly ash : Observed[ ] Not observed[X]

VOIDS

% of total volume : 5-7 % Visual estimate[X] Point count[ ]
Distribution : Even[ ] Uneven[ ] Clustered[X]
Shape : Spherical[ ] Nonspherical[ ] Ellipsoidal[ ] Irregular[X]
Entrained air : Air-entrained[ ] Non-air-entrained[X]
Interior lustre : Dull[X] Shining[ ]
** Interior condition: Empty[X] Lined[X] Partly filled[ ] Totally filled[ ]
% Voids with mineralization: Most[ ] About half[ ] Few[X] None[ ]
Mineralization : Alkali-silica gel[X] Ettringite[ ] Portlandite[X]
Calcium carbonate[X]

CRACKS

Amount : Extensive[ ] Occasional[ ] None[X]
Continuity and Distribution:

Orientation : Vertical[ ] Horizontal[ ] Random[ ]
Location : Through aggregate particles[ ] Around aggregate particles[ ]
Width (mm) : Range to Average
% filled : %
Filling material: Alkali-silica gel[ ] Ettringite[ ] Portlandite[ ]
Calcium carbonate[ ] Other:
Associated with embedded items: Yes[ ] No[ ]

EMBEDDED ITEMS Yes[ ] No[X]

Description:
Condition : Clean[ ] Corroded[ ] Decayed[ ]
Size (mm) :
Location/Orientation:
Other :

GENERAL COMMENTS:
* Results are based on a visual examination of a core section only, and not all items listed above could be evaluated.
** Most of the voids were empty. A few voids were partly lined with alkali-silica gel and calcium carbonate.

Distribution: MR. E.J. MCCOLM CIVIL RESEARCH
MR. J. VITANYI/MR. M.F. EVERITT CIVIL RESEARCH
842.5 AUB KR163
852.5 (P) OFFICIAL RECORD

Approved by: _____ Submitted by: _____
Report No.: SN91-2-K

ONTARIO HYDRO RESEARCH DIVISION
PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE
ADAPTED FROM: ASTM C 856

Project: AUBURN GS
Region : CENTRAL
Structure: TRAINING WALL
Area: PETERBOROUGH
Report No.: SN91-3-K
Job No.: 42-179-481
File No.: 842.5 AUB
Date Issued: 91.02.13

Sample Type : Core[X] Cylinder[ ] Chunk[ ] Other[ ]

Sample Description: Section (interval 750 to 1000 mm, nominal 86 mm diameter) of Core 5, drilled vertically from the training wall. The concrete has undergone approx. 80 years of exposure in an environment of high rel. humidity

* Sample Preparation: Freshly broken/saw cut/drilled surface[X] Polished face[ ]
Weathered surface[ ] Thin Section[ ]/No.

CONCRETE

Hit with hammer	: Ring[X]	Dull[ ]		
Break with fingers	: Particles not dislodged[X]	Powdery[ ]	Friable[ ]	
During sawing	: Clean cut[X]	Breaks easily[ ]		
Cement/coarse aggregate bond	: Good[X]	Partial[ ]		Poor[ ]
Cement/fine aggregate bond	: Good[X]	Partial[ ]		Poor[ ]
Presence of honeycombing	: Not observed[X]	Minor[ ]		Extensive[ ]

COARSE AGGREGATE

Source	: Unknown - construction records unavailable.			
% of total volume	: 30-35 %	Visual estimate[X]		Point count[ ]
Material type	: Gravel[X]	Quarried[ ]	Mixture[ ]	Other[ ]
Shape	: Rounded[X]	Partly crushed[ ]		100% Crushed[ ]
Distribution	: Even[ ]	Uneven[X]		Chaotic[ ]
Nominal size	: 40 (mm)			
Maximum size	: 40 (mm)			
Preferred orientation	: Present[ ]	Not observed[X]		

LITHOLOGICAL TYPE	% OF COARSE AGGREGATE	REACTION RIMS/GEL/ FRACTURES	REMARKS
Limestone	100	A few tight fractures. Fractures do not extend into the cement paste.	--

FINE AGGREGATE

Source	: Unknown - construction records unavailable.				
% of total volume	: 30-35 %	Visual estimate[X]			Point count[ ]
Material type	: Natural[X]	Manufactured [ ]	Mixture[ ]		Other[ ]
Shape	: Rounded[X]	Subrounded[X]	Subangular[ ]		Angular[ ]
Distribution	: Even[X]	Uneven[ ]			Chaotic[ ]
Perferred orientation	: Present[ ]	Not observed[X]			

CEMENT MATRIX

% of total volume : 15-20 % Visual estimate[X] Point count[ ]
Appearance of broken surface: Subtransluescent[ ] Dull[X] Chalky[ ]
Colour : Grey[ ] Light grey[X] White[ ] Brown[ ] Other:
Colour distribution: Even[X] Mottled[ ] Gradational[ ]
Bleeding : Extensive[ ] Minor[X] Not observed[ ]
Carbonation : Surficial only[ ] Along fractures[ ] Partial[ ] Total[ ]
Slag cement : Observed[ ] Not observed[X]
Fly ash : Observed[ ] Not observed[X]

VOIDS

% of total volume : 5-7 % Visual estimate[X] Point count[ ]
Distribution : Even[X] Uneven[ ] Clustered[ ]
Shape : Spherical[ ] Nonspherical[ ] Ellipsoidal[ ] Irregular[X]
Entrained air : Air-entrained[ ] Non-air-entrained[X]
Interior lustre : Dull[X] Shining[ ]
** Interior condition: Empty[X] Lined[ ] Partly filled[X] Totally filled[ ]
% Voids with mineralization: Most[ ] About half[ ] Few[X] None[ ]
Mineralization : Alkali-silica gel[X] Ettringite[X] Portlandite[X]
Calcium carbonate[ ]

CRACKS

Amount : Extensive[ ] Occasional[ ] None[X]
Continuity and Distribution:

-

Orientation : Vertical[ ] Horizontal[ ] Random[ ]
Location : Through aggregate particles[ ] Around aggregate particles[ ]
Width (mm) : Range to Average
% filled : %
Filling material: Alkali-silica gel[ ] Ettringite[ ] Portlandite[ ]
Calcium carbonate[ ] Other:
Associated with embedded items: Yes[ ] No[ ]

EMBEDDED ITEMS Yes[ ] No[X]

Description:
Condition : Clean[ ] Corroded[ ] Decayed[ ]
Size (mm) :
Location/Orientation:
Other :

GENERAL COMMENTS: * Results are based on a visual examination of a core section and not all items listed above could be evaluated.
** Alkali-silica gel was found in three voids on the top surface at the core break. In general, the voids were empty, although many were dotted with minute tufts of ettringite.

Distribution: MR. E.J. MCCOLM CIVIL RESEARCH
MR. J. VITANYI/MR. M.F. EVERITT CIVIL RESEARCH
842.5 AUB KR163
842.5 (P) OFFICAL RECORD

Approved by: _____ Submitted by: _____
Report No.: SN91-3-K

PETROGRAPHIC EXAMINATION OF HARDENED CONCRETE
ADAPTED FROM: ASTM C 856

Project: AUBURN GS — Job No.: 42-179-481
Region : CENTRAL — Area: PETERBOROUGH — File No.: 842.5 AUB
Structure: EAST RETAINING WALL — Report No.: SN91-4-K — Date Issued: 91.02.13

Sample Type : Core[X] Cylinder[ ] Chunk[ ] Other[ ]

Sample Description: Section (interval 300 to 500 mm, nominal 99 mm diameter) of Core 6 drilled horizontally from the east retaining wall. The concrete has undergone approx. 80 years of exposure in an environment of high rel. humidity

* Sample Preparation: Freshly broken/saw cut/drilled surface[X] Polished face[ ] Weathered surface[ ] Thin Section[ ]/No.

CONCRETE

Hit with hammer	: Ring[X]	Dull[ ]	
Break with fingers	: Particles not dislodged[X]	Powdery[ ]	Friable[ ]
During sawing	: Clean cut[X]	Breaks easily[ ]	
Cement/coarse aggregate bond	: Good[ ]	Partial[X]	Poor[ ]
Cement/fine aggregate bond	: Good[X]	Partial[ ]	Poor[ ]
Presence of honeycombing	: Not observed[X]	Minor[ ]	Extensive[ ]

COARSE AGGREGATE

Source	: Unknown - construciton records unavailable.			
% of total volume	: 30-35 %	Visual estimate[X]		Point count[ ]
Material type	: Gravel[X]	Quarried[ ]	Mixture[ ]	Other[ ]
Shape	: Rounded[X]	Partly crushed[X]		100% Crushed[ ]
Distribution	: Even[ ]	Uneven[X]		Chaotic[ ]
Nominal size	: 40 (mm)			
Maximum size	: 75 (mm)			
Preferred orientation	: Present[X]	Not observed[ ]		

LITHOLOGICAL TYPE	% OF COARSE AGGREGATE	REACTION RIMS/GEL/ FRACTURES	REMARKS
Limestone	70-75	No reaction rims or gel observed. A few of the aggregates are fractured. Generally these fractures do not extend into the cement paste.	--
Granite gneiss	25-30	Same as above.	--

FINE AGGREGATE

Source	: Unknown - construction records unavailable.				
% of total volume	: 40-45 %	Visual estimate[X]			Point count[ ]
Material type	: Natural[X]	Manufactured [ ]	Mixture[ ]		Other[ ]
Shape	: Rounded[X]	Subrounded[X]	Subangular[ ]		Angular[ ]
Distribution	: Even[X]	Uneven[ ]			Chaotic[ ]
Perferred orientation	: Present[ ]	Not observed[X]			

CEMENT MATRIX

% of total volume : 10-15 % Visual estimate[X] Point count[ ]
Appearance of broken surface: Subtransluescent[ ] Dull[X] Chalky[ ]
Colour : Grey[ ] Light grey[X] White[ ] Brown[ ] Other:
Colour distribution: Even[X] Mottled[ ] Gradational[ ]
Bleeding : Extensive[ ] Minor[ ] Not observed[X]
Carbonation : Surficial only[ ] Along fractures[ ] Partial[ ] Total[ ]
Slag cement : Observed[ ] Not observed[X]
Fly ash : Observed[ ] Not observed[X]

VOIDS

% of total volume : 1-3 % Visual estimate[X] Point count[ ]
Distribution : Even[X] Uneven[ ] Clustered[ ]
Shape : Spherical[ ] Nonspherical[X] Ellipsoidal[ ] Irregular[ ]
Entrained air : Air-entrained[ ] Non-air-entrained[X]
Interior lustre : Dull[X] Shining[ ]
Interior condition: Empty[X] Lined[ ] Partly filled[ ] Totally filled[ ]
% Voids with mineralization: Most[ ] About half[ ] Few[ ] None[X]
Mineralization : Alkali-silica gel[ ] Ettringite[ ] Portlandite[ ]
Calcium carbonate[ ]

CRACKS

Amount : Extensive[ ] Occasional[X] None[ ]
Continuity and Distribution: Discontinuous, tight (<0.1 mm wide) fractures are randomly orientated throughout the specimen.

Orientation : Vertical[ ] Horizontal[ ] Random[X]
Location : Through aggregate particles[X] Around aggregate particles[X]
Width (mm) : Range 0.0 to 0.1 Average <0.1
% filled : <10 %
Filling material: Alkali-silica gel[ ] Ettringite[ ] Portlandite[X]
Calcium carbonate[X] Other:
Associated with embedded items: Yes[ ] No[X]

EMBEDDED ITEMS Yes[ ] No[X]

Description:
Condition : Clean[ ] Corroded[ ] Decayed[ ]
Size (mm) :
Location/Orientation:
Other :

GENERAL COMMENTS: The coarse aggregate is poorly graded, having very few medium-sized (14mm to 40mm) particles. Some coarse aggregates do show a preferred orientation with the long axis perpendicular to the direction of concrete placement.
* Results are based on a visual examination of a core section only.

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